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SEDIMENTATION, VOLCANISM, AND ANCESTRAL LAKES IN THE VALLES MARINERIS: CLUES FROM TOPOGRAPHY; **B.K. Lucchitta, N.K. Isbell, and A. Howington-Kraus**, U.S. Geological Survey, Flagstaff, AZ 86001.

Abstract. Compilation of a simplified geologic/geomorphic map onto a digital terrain model of Valles Marineris has permitted quantitative evaluations of topographic parameters. The study showed that, if their interior layered deposits are lacustrine, the ancestral Valles Marineris must have consisted of isolated basins. If, on the other hand, the troughs were interconnected as they are today, the deposits are most likely of volcanic origin, and the mesas in the peripheral troughs may be table mountains. The material eroded from the trough walls was probably not sufficient to form all of the interior layered deposits, but it may have contributed significantly to their formation.

Method. We prepared a geologic/geomorphic map of the Valles Marineris, simplified and modified from Witbeck et al. [1], transferred it to existing topographic maps, and digitized and co-registered it with the digital terrain models (DTMs) of the topographic maps. We then calculated areas occupied by the individual map units. We also calculated the depth of troughs and the volume of void spaces above individual units by obtaining the difference between the DTMs and a restored surface linking the adjacent plateaus across the troughs. Finally, we calculated volumes of interior deposits by obtaining the difference between the DTMs and a designated "floor" under the deposits. (Details of the method were given in a previous report [2].) We then analyzed the results of the various topographic and volume relations in regard to erosional and structural implications for the history of the Valles Marineris.

Central troughs. The favored hypothesis for the origin of the interior layered deposits is that they are sediments emplaced in lakes. However, in Ophir and Candor Chasmata, lakes could not have been sustained if all the troughs were interconnected; lake waters in these troughs must have reached a 9-km elevation in order to lay down the uppermost layered deposits. These high-standing lakes would have spilled out of Coprates Chasma onto the surrounding plateaus that have surface elevations of only 4-5 km. If the lakes were interconnected, their levels inside the central troughs could not have been higher than about 4 km. Thus, at least the upper interior layered deposits cannot be lake sediments. A likely alternative is that they are volcanic.

On the other hand, the troughs may not have been interconnected but may have formed isolated basins when the interior layered deposits were emplaced. As also shown by independent structural and stratigraphic evidence, these ancestral basins occupied the southern parts of Ophir, Candor, and Melas Chasmata [3]. The northern parts of these troughs and the entire Coprates/north Melas/Ius graben system may have formed later, after deposition of the interior layered deposits had ceased.

Peripheral troughs. The peripheral troughs Juventae, Gangis, and Capri/Eos Chasmata, reaching depths of 2-5 km, are shallower than the central troughs. Our investigation showed that they most likely formed from a combination of erosional collapse and structural activity. Furthermore, the existence of chaotic material in these troughs at similar elevations (near the 4-km contour on the adjacent plateau surfaces) supports the idea that the chaotic material may have indeed formed from release of confined artesian water [4]. In the peripheral troughs, the interior layered deposits bury chaotic material, indicating that lakes formed after the chaotic collapse of the surface (if the layered deposits are indeed lake sediments). The lakes were apparently breached only later to form the presently observed outflow channels. However, the layered deposits in these troughs may not be lake sediments at all; they may be volcanic materials, as is perhaps true for the central troughs. A volcanic composition is suggested because in Gangis and Juventae Chasmata the layered deposits occur in free-standing mesas that have the shape of table mountains in Iceland [5], a form supporting sub-ice emplacement. The volcanic materials could have been erupted below segregated ice masses postulated to have existed in those areas [6], or they could have formed in shallow, completely frozen lakes. The main scarps of the mesas rise about 2 km or less above the trough floors, a thickness consistent with the depth of frozen ground in the equatorial area [7].

Redeposition of wall material. The troughs were significantly widened by erosion, but volumetric comparisons and topographic and geomorphic analyses show that material eroded from trough walls may not have been sufficient to be the sole source for interior layered deposits. Even though the total eroded and deposited volumes match approximately, to fill Ophir and Candor Chasmata with eroded wall material from Coprates and Ius Chasmata would have required uphill transport of material into the central troughs, which is an improbable concept. Also, the Coprates/north Melas/Ius system may not yet have existed at the time of layered-deposit emplacement; if it did not, the amount of material eroded from trough walls at that time would have been only about half as much as the estimated total. Because of these considerations, it is likely that other material contributed to the formation of layered deposits. Some may have come from subterranean piping and some from volcanism.

History. A brief history of the Valles Marineris, based on the above observations, can be envisioned as follows. In the region of the central troughs, ancestral deep basins formed partly from collapse, partly from structural adjustment along previous structural alignments. These basins, which may have contained lakes, were filled with material from the eroding walls and perhaps with some materials from subterranean piping and volcanism. Probably at the same time as formation of the deep basins, the peripheral troughs formed, mostly by collapse due to eruption of artesian water. In these troughs, layered deposits were also emplaced in ancestral lakes, which were eventually drained by the outflow channels we see today. Later, the central basins were widened and deepened by the addition of subsidiary northern grabens. The Coprates/north Melas/Ius graben system cut the entire region, including the ancestral Melas Chasma. These new grabens connected the troughs with one another and with the peripheral troughs in the east. When all the troughs merged, a major flood may have emptied the central troughs, but more likely lakes in those troughs had already dried up because they were filled with sediments and volcanic material.

Alternatively, all troughs were already interconnected early in their development. No deep lakes formed, and thus the layered deposits are probably largely of volcanic origin. Volcanic material in the peripheral troughs may have been emplaced as table mountains.

Even though both scenarios are within the constraints of the topographic analysis, a combination of them is probably closer to reality. The troughs likely contain both volcanic and mass-wasted materials emplaced in a series of basins that eventually interconnected. The existence of former lakes is more questionable for the central troughs than for the peripheral troughs.

References

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